TMM014- Technical Mathematics I Guidelines (Draft- January 2020)

Typical Range: 3-4 Semester Hours

A course in Technical Mathematics specializes in the application of mathematics to the engineering technologies. The course emphasizes critical thinking by placing students in problem-solving situations and supporting students as they learn to make decisions, carry out plans, and judge results. Students encounter contextualized situations where concepts and skills associated with measurement, algebra, geometry, trigonometry, and vectors are the pertinent tools. The course highlights the supporting algebraic and analytical skills.

Rather than an Algebra course supplemented with applications, Technical Mathematics (TMM014) is intended to follow the spirit of a Quantitative Reasoning course. Instead of lectures presenting skills and procedures followed by practice activities, we hope this course will place students in situations where the mathematics become the tools for investigation. Applications should be the foundation of a collaborative experience, where groups of students make decisions, choose tools, follow plans, draw conclusions, and explain their reasoning.

To qualify for TMM014 (Technical Mathematics I), a course must achieve all of the following essential learning outcomes listed in this document (marked with an asterisk). The Sample Tasks illustrate the level of student engagement motivating this course.

1. **Geometry:** Successful Technical Mathematics students are able to visualize and identify geometric aspects and relationships within a given situation. Students can use these relationships to disseminate measurements throughout the situation. By reasoning with geometric properties, students can target specific information and explain their thought process.

   The successful Technical Mathematics student can:

   1a. recognize and apply properties of 2D shapes. Students recognize shapes within diagrams and use shapes in creating representations of situations. By selecting appropriate aspects and characteristics of the geometric shapes, students can extend a situational description via related lengths and areas. Through similar shapes and classifications, students explain their approach to problem solving. *

   1b. recognize and apply properties of 3D shapes. Students visualize 3D situations and navigate around the picture or diagram. Through the use of common 3D shapes, students calculate volumes need for further calculations. *

   1c. recognize and apply properties of angles. Student measures angles in degrees, radians, and DMS. Angular relationships, together with obtained or given angular measurements, are combined by student to elaborate about further angular measurements. *

1d. apply the Pythagorean Theorem. The student can identify right angle triangles in a diagram and attribute given measurements to the proper aspects. With this information, the student can use the Pythagorean Theorem to deduce other measurements. *

2. Measurement: Successful Technical Mathematics students are comfortable with measurements and their representations. Students anticipate types and classifications of measurements and use their expectations to formulate lines of investigation. Students obtain, convert, compare, and combine measurements. They express measurements in a variety of ways.

The successful Technical Mathematics student can:

2a. reason with amount measurements. Students distinguish qualities, characteristics, and aspects of objects in situations that can be measured. They connect units with appropriate measurement type. They convert units, and abbreviations, for similar types of measurements and can properly use units when discussing measurements. *

2b. reason with rate measurements. Students express rates as phrases, equations, and fractions. They compare the changing amounts described by rates. They can convert units and reason for the needed rate. *

2c. can communicate about measurements. Students communicate fluently with units, abbreviations, and notation whether this be verbally or in writing. They calculate accurately with decimals, fractions, percentages, scientific notation, and engineering notation. They do so with information they have deciphered from tables and graphs. *

3. Equations, Inequalities, & Graphs: Successful Technical Mathematics students are proficient at algebraic procedures and manipulating measurements via equations, inequalities, and graphs. Students can express dependence and independence via equations and calculate resulting measurements via formulas. These calculations might be numeric, but more than likely, students should feel comfortable with the algebra of measurements.

The successful Technical Mathematics student can:

3a. algebraically manipulate expressions and equations and inequalities. Students are fluent in the use of arithmetic and algebra rules, especially fractions. They predict effects of changes in variables. They solve equations for dependent variables. They model situations with linear and quadratic equations. *

3b. combine algebraic and graphical representations. Students are proficient with all representations used to describe information and measurements. In particular, students competently use lines and linear equations to describe real-world relationships. *

3c. solve systems of equations. Students can create systems of linear equations from given situations and then solve them via various techniques. *

3d. row reduce a matrix. Students can row reduce an augmented matrix to solve systems of linear equations. *

4. Dimensional Analysis: Successful Technical Mathematics students are proficient at combining measurements. Dimensions simply refers to products of measurements, which naturally emerge when working with rates. Students reason through the connecting changes described by the rates and manipulate units symbolically via exponential forms.

The successful Technical Mathematics student can:

4a. explain representations of amounts and rates. Students express the meaning of the representational fraction as a rate. *

4b. manipulates algebraic representations of amounts and rates. Students algebraically manipulate rates written as fractions. They can reduce and simplify products of rate fractions using the properties of exponents. *

5. Trigonometry: Successful Technical Mathematics students demonstrate an ability to use triangles. Students generate a triangle mesh as needed to combine given information together and propagate a chain of measurements toward a desired target.

The successful Technical Mathematics student can:

5a. identify right triangles in situations. Students identify right triangular configurations in diagrams and assign given measurements to the proper pieces of the triangles. *

5b. apply trigonometric functions. Students identify which pieces of a right triangle are given and apply sine, cosine, and tangent functions to obtain further measurements. They use calculators to evaluate expressions involving trigonometric functions. They apply the Laws of Sine and Cosine appropriately. *

5c. apply inverse trigonometric functions. Students recognize if questions are asking for lengths or angle measurements and can phrase a solution plan. Using calculators, students can obtain angular measurements from linear measurements. *

5d. analyze and compare basic sine and cosine graphs. Students can graphically determine amplitude, period, phase shift, etc. *

6. Vectors: Successful Technical Mathematics students are proficient with vectors. Students rephrase information in terms of vectors and easily moving between components and resultants.

The successful Technical Mathematics student can:

6a. represent vectors. Students represent vectors algebraically and graphically in either rectangular or polar coordinates. *

6b. perform arithmetic with vectors. Students represent vectors algebraically and graphically and perform arithmetic operations in either mode. *

6c. Decompose vectors. Students decompose measurements into components relative to given coordinate systems. *

7. Complex Numbers: Successful Technical Mathematics students are comfortable with the arithmetic of complex numbers as well as their basic Geometry.

The successful Technical Mathematics student can:

7a. perform arithmetic with complex numbers. Add, subtract, multiply, and divide. *

7b. connect algebraic expressions with points in the plane. $a + bi$ associated with (a, b). *

7c. map complex arithmetic with vector arithmetic. *

8. Functions: Successful Technical Mathematics students are proficient with dependencies. Students analyze the effect on dependent quantities from changes in independent quantities, whether this dependency is described algebraically or graphically.

The successful Technical Mathematics student can:

8a. communicate via function notation. *

8b. evaluate functions via formulas or graphs. *

8c. obtain graphs via technology given formulas. *

8d. analyze function behavior graphically. (increasing/decreasing, maximums/minimums) *

8e. work explicitly with linear functions *

8f. work explicitly with quadratic functions. *

8g. evaluate, graph, and graphically analyze exponential functions. *